Learning Objectives

1. Classify spines based on their morphology (Q1)
2. Calculate proportion of spine subtypes (spine fraction) and spine density (Q2)
3. Explain the relationship between spine morphology and long-term potentiation and long-term depression (Q3-8)
4. Use spine morphology data to make hypotheses about behavioral phenotypes (Q9,10,13)
5. Reflect on unexpected experimental results and determine nature of error/troubleshoot (Q11, 12)

Pre/Post Test

1. Match the indicated spine to the correct spine morphology (**1/2 point apiece**)
   A: ½ **pt if thin or long thin; ¼ pt if filopodia**
   B: ½ pt if mushroom
   C: ½ pt if branched, or mushroom turning into a branched synapse
   D: ½ pt if stubby

2. Calculate the **spine fraction** for each morphological type based on the data below. Show your work. Round to the nearest tenth. (1/4 point for each correct answer)
   a. Thin; 0.07
   b. Stubby 0.56
   c. Mushroom 0.28
   d. Branched 0.07

Spine type	# counted
Thin	10
Mushroom	80
Branched	10

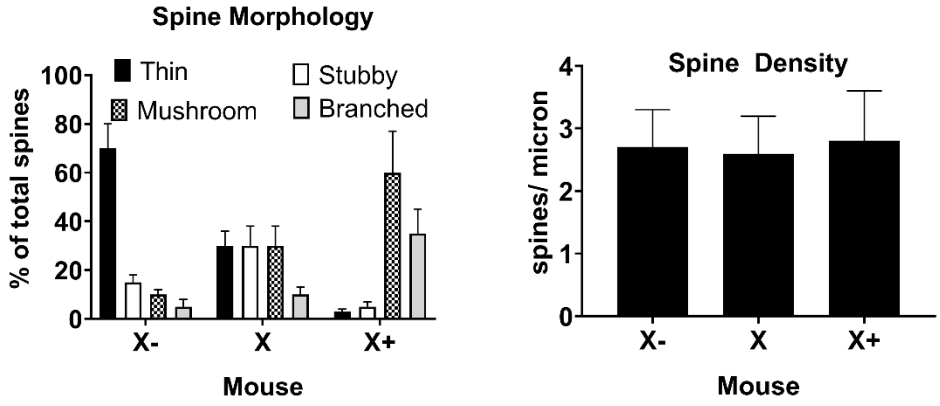
Stubby	40

3. Which of the following statements is true? (Select all that apply) (**1/2 pt apiece**)
   - **a. Long-term potentiation at a synapse can cause the postsynaptic stubby spine to transform into a mushroom spine**
   - b. Long-term potentiation at a synapse can cause the postsynaptic mushroom spine to transform into a stubby spine
   - c. Long-term depression at a synapse can cause the postsynaptic thin spine to transform into a mushroom spine
   - **d. Long-term depression at a synapse can cause the postsynaptic stubby spine to transform into a thin spine**

4. Rank the following spines from weakest to strongest: Stubby, Branched, Thin, Mushroom
   All or none: must be thin, stubby, mushroom, branched for 1 pt.

You are investigating the role of protein X on spine density, morphology, and learning.

You tested the role of this protein in three difference mice. One mouse (X-) has protein X removed. Another mouse (X) has normal levels of protein X. Lastly, the last mouse (X+) has very high levels of protein X.



5. What conclusions can you draw about the role of protein X in controlling **spine morphology**? **(1pt)**
   +1 for indicating that more of protein X produces more mature spines (or its converse). ½ point if student states that protein X plays a role in spine maturation.

6. What does your answer to Questions 5 imply about the role of protein X in controlling synaptic strength? (1pt)

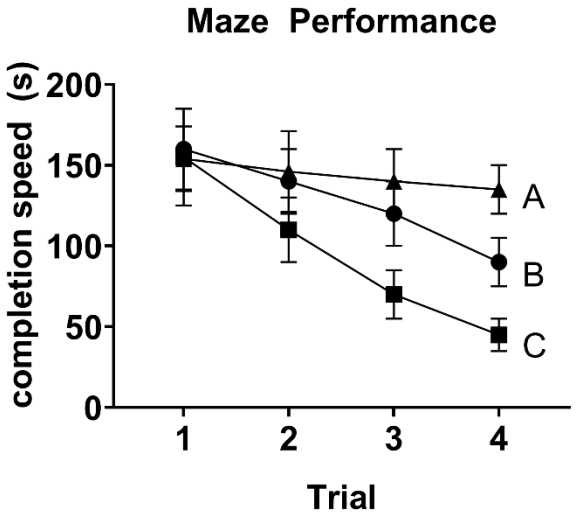
+1, must indicate that more of protein X can increase synaptic strength since more mature synapses will generally have higher LTP (or its converse). 1/2 a point if student states that protein X plays a role in synaptic strength.

7. What conclusions can you draw about the role of protein X in controlling **spine density**? (1pt)
Protein X does not play a major role + 1

8. You administer a drug which is known to cause long-term depression at synapses. Which mouse will most likely have the greatest changes? **(1pt)**
X+, since long-term depression will weaken synapses (make them less strong and less mature), and this mouse has the most mature/strong synapses, this drug will likely have the most effect. (+1)

Alternatively, a student may suggest that it is NOT X+, since the synapses are so strong that it might be harder to initiate LTD. (+1)

9. You ran the three mice (X-. X, and X+) through a learning maze, but you have mixed up the learning maze data. You cannot tell which data belongs to which mouse.



Based on your answers to question 6, indicate which learning maze data belongs to which mouse. **(1pt)**

The learning maze data labeled "A" belongs to _____.

The learning maze data labeled "B" belongs to _____.

The learning maze data labeled "C" belongs to _____.

See Question 10

10. Justify your response to 9 (1pt).

1 point if they have an order that is reasonable based on Question 9 (A= X-, B = X, and C = X+, that will only be correct if they then say that the reason X+ learns better is due to better learning. If they make a mistake and misinterpret the learning maze and end up saying A = X+, but then have the justification is OK (e..g., more spines = better learning, then 0.5 pts will be docked). Many ways to get points in Question 10: X+ more mature spines = better learning, or that X does best learning since X+ could be maxxed out on maturity (can't strengtehn spines that are already super strong). Partial (0.5) pts will be given for answers in which they might say that X is better than X+ (or vice versa, with valid reason), but X - is better than X (invalid reason)

11. Two students independently analyzed the same data (presented below). Based on these data, what is the largest discrepancy(ies) between their data? Why do you think this discrepancy occurred? (**1pt**)

	Student A	Student B
Thin	10	12
Stubby	34	62
Mushroom	60	30
Branched	2	1

+0.5 pts for indicating that there was a mixup between stubbies and mushrooms
+0.5 pts for indicating it is because of differences in classification/ because they are sometimes hard to discriminate between.

12. In 11 and 12, which of the following would be an appropriate way to resolve these differences? **(1pt)** Select all that apply
    a. **Analyze the data together, going spine by spine and debating the morphology**
    b. Ignore that there is a discrepancy since this is a subjective analysis, and average the data between the two students
    c. Pick only one or the other student's answers
    d. All of the above
    e. None of the above

13. Which of the following might occur if a mouse is given an injection of an NMDA antagonist right before learning a new maze (select all that apply) (1pt)
    a. **They will learn the maze faster than mice given the NMDA antagonist**

b. They synapses that are involved in learning this maze will become more mature and strengthen compared to mice not given an NMDA antagonist
c. The synapses that are involved in learning this maze will not increase in strength/morphology, compared to mice not given an NMDA antagonist
d. They will learn the maze slower than mice given the NMDA antagonist